

8 meter Advanced Technology Large-Aperture Space Telescope (ATLAST-8m)

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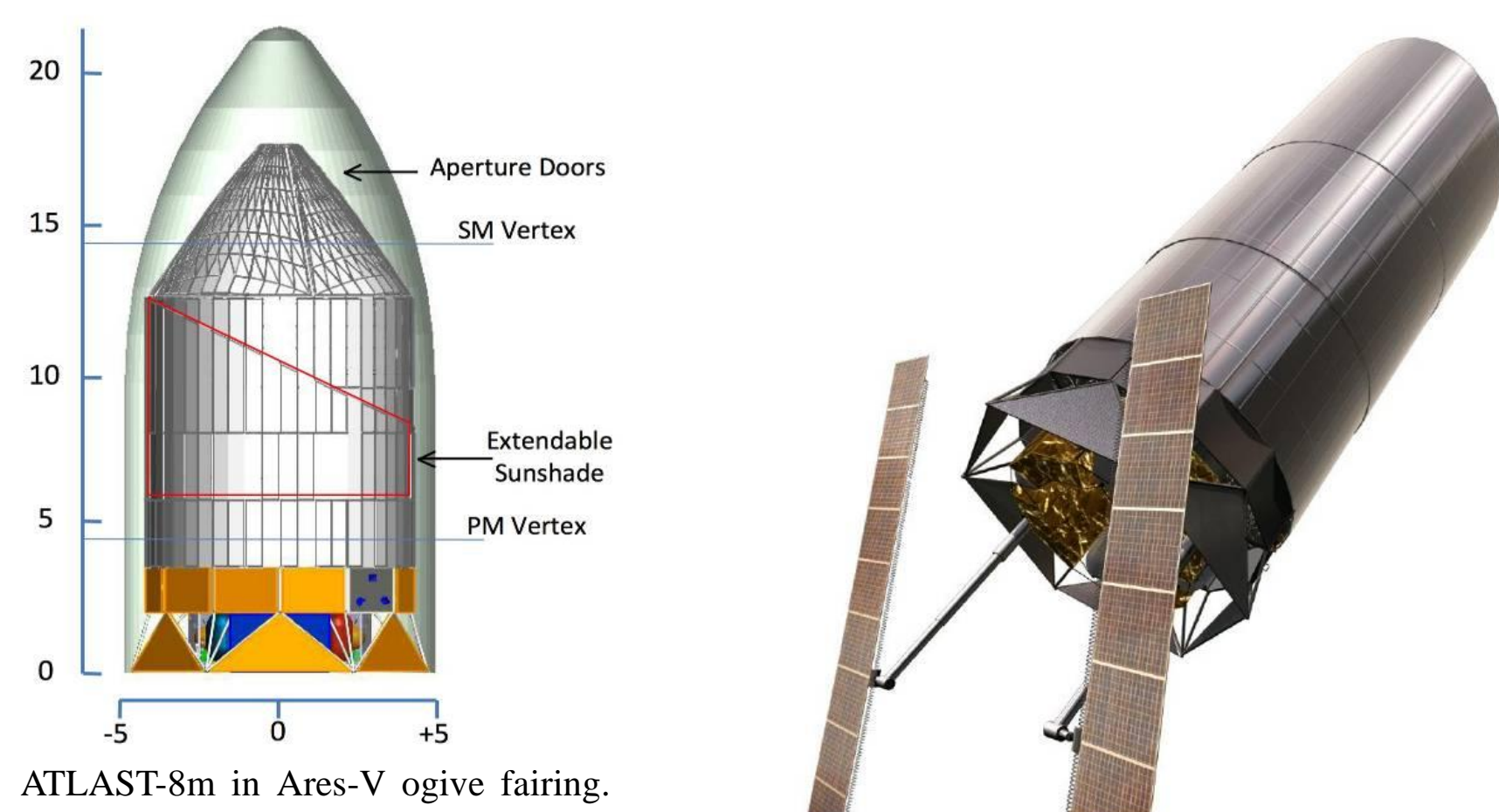
Abstract

ATLAST-8m (Advanced Technology Large Aperture Space Telescope) is a proposed 8-meter monolithic UV/optical/NIR space observatory (wavelength range 110 to 2500 nm) to be placed in orbit at Sun-Earth L2 by NASA's planned Ares V heavy lift vehicle. Given its very high angular resolution (15 mas @ 500 nm), sensitivity and performance stability, ATLAST-8m is capable of achieving breakthroughs in a broad range of astrophysics – including: Is there life elsewhere in the Galaxy? An 8-meter UVOIR observatory has the performance required to detect habitability (H₂O, atmospheric column density) and biosignatures (O₂, O₃, CH₄) in terrestrial exoplanet atmospheres, to reveal the underlying physics that drives star formation, and to trace the complex interactions between dark matter, galaxies, and intergalactic medium.

The ATLAST Astrophysics Strategic Mission Concept Study developed a detailed point design for an 8-m monolithic observatory including: optical design; structural design/analysis including primary mirror support structure, sun shade and secondary mirror support structure; thermal analysis; spacecraft including structure, propulsion, GN&C, avionics, power systems and reaction wheels; mass and power budgets; and system cost. The results of which were submitted by invitation to NRC's 2010 Astronomy & Astrophysics Decadal Survey.

Mission Concept

ATLAST-8m would be launched from KSC on an Ares V launch vehicle (configuration 51.01.48), which can place 65 mt of payload into a halo orbit about the second Sun-Earth Lagrange point (SE-L2) using a direct insertion trajectory. ATLAST-8m fits easily inside the baseline Ares V fairing with its 10 m diameter fairing. Once on-orbit, the 60 degree scarfed forward sunshield slides forward, the protective doors open, the solar panels deploy and the optical component launch locks release.



The wavefront sensing and control system iteratively uses star trackers and fine guidance sensors to point stars onto phase-diversity sensors distributed about the observatory field of view. Alignment is achieved by moving the secondary mirror via its hexapod and if necessary the tertiary mirror. ATLAST-8m carries sufficient propellant for a 20 year (or longer) mission. Analysis indicates that only 5 m/s delta-v is needed per year for station keeping and momentum unloading. Operational constraints allows the telescope to see the entire sky over six months.

Simplicity, Low Risk and Cost

ATLAST-8m uses the unparalleled capabilities of NASA's planned Ares V launch vehicle to design a simple low risk observatory using high TRL (but massive) technology for a lower total cost.

Space telescopes without a launch mass constraint tend to be 10X more massive and 60% lower cost than those with a design to mass constraint.

ATLAST-8m uses mass to provide a mechanically stable telescope with precision pointing; and a 10X launch load margin of safety.

The key ATLAST-8m idea is to use a 'conventional' 8-m ground-based telescope mirror instead of a lightweight mirror. It is proven that such mirrors can be manufactured with the necessary precision to enable high-contrast imaging for exo-planet science.

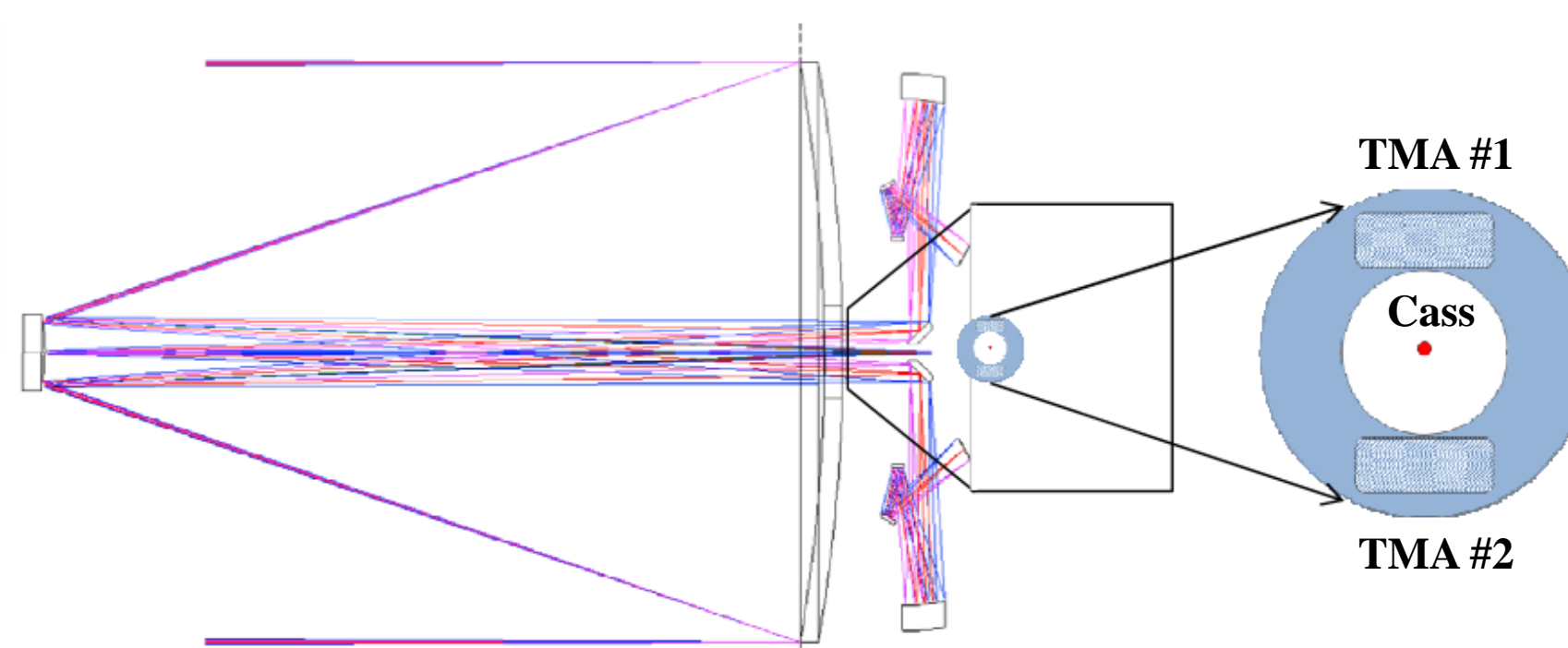
Given its enormous thermal mass, it is virtually immune to transient thermal events. The primary mirror thermal time constant is 500 hrs to produce a 1 nm rms figure change.

Finally, Ares V volume allows the launch of a fully deployed telescope.



Optical Design

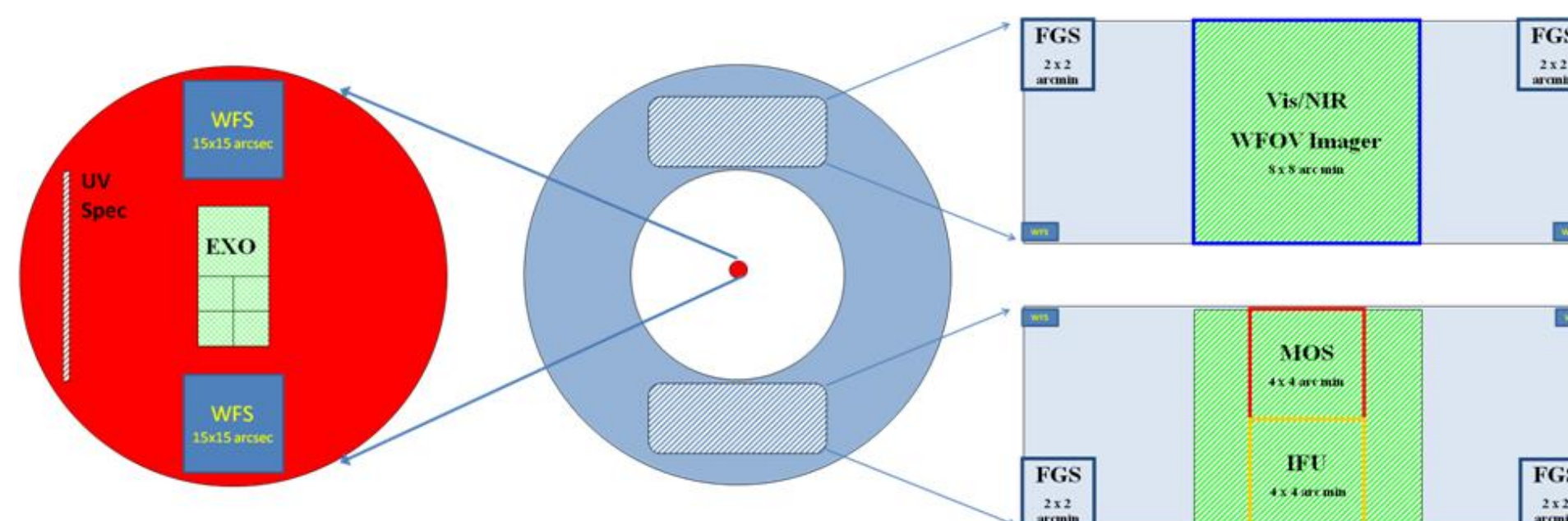
ATLAST-8m OTA has a dual-field design with three foci. All three foci are diffraction limited at 500 nm. The main telescope is a two-mirror system, which forms a narrow-field-of-view 1 arc-min Cassegrain (CASS) image (red dot in graphic). Pick-off mirrors, on either side of CASS focus, direct off-axis portions of the Cassegrain image plane to tertiary-mirror aft-optics assemblies, which form two wide-field-of-view (WFOV) 8 x 22 arc-min three-mirror anastigmatic (TMA) images. The TMA provides a 13 mas plate scale. All three foci are directly accessible to a 4.0 m diameter by 4.5 m deep instrument bay centered on-axis behind the primary mirror.



TMA FOVs are separated on the sky by approximately 0.5 degrees. This separation helps the FGS pointing system control roll well enough to meet the 1.6 mas pointing stability requirement.

Science Instruments

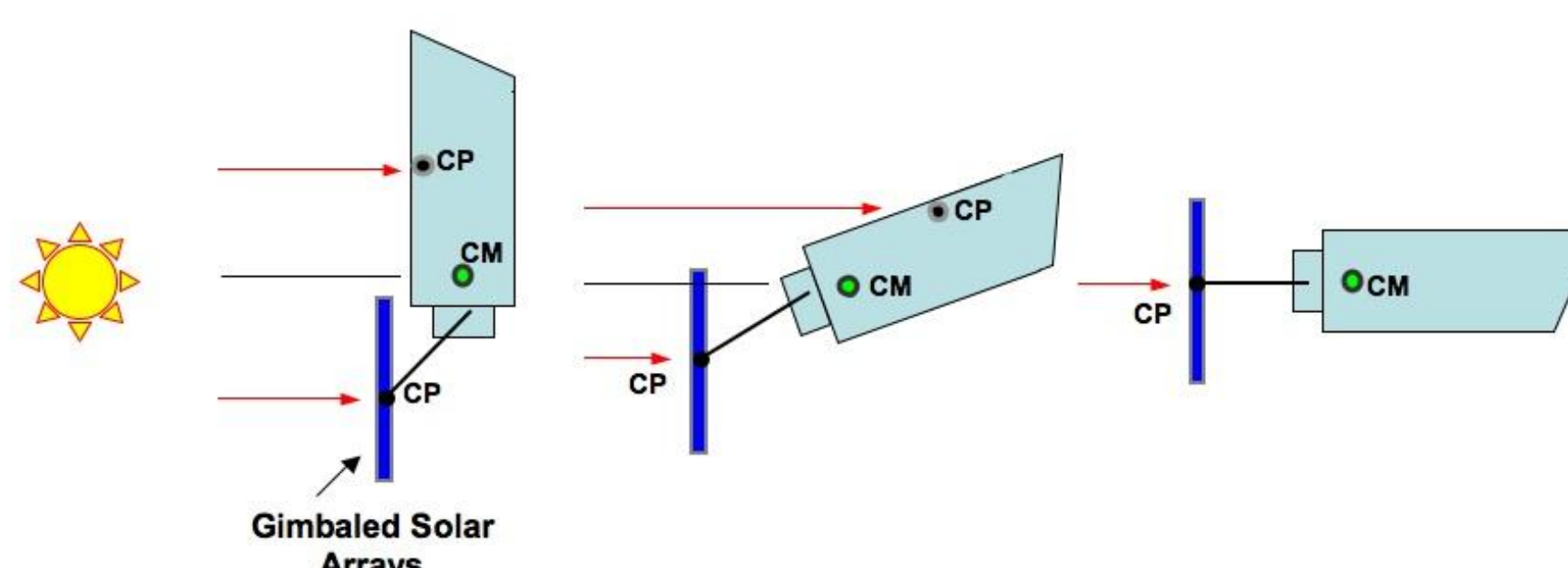
The baseline concept has 5 science and 2 facility instruments. The exoplanet instrument suite and UV spectrometer are at CASS focus. The WFOV imager, multi-object spectrograph and IFU spectrograph are at the TMA foci. All three have wavefront sensors and each TMA foci has two Fine Guidance Sensors (FGS).



Each instrument is a self-contained On-orbit Replaceable Unit (ORU) using HST-style mounting rails accessible from the back of the instrument bay to facilitate servicing. IC&DH controls telescope mechanisms and heaters, wavefront sensing (WFS) processors, and science instruments.

Attitude Control

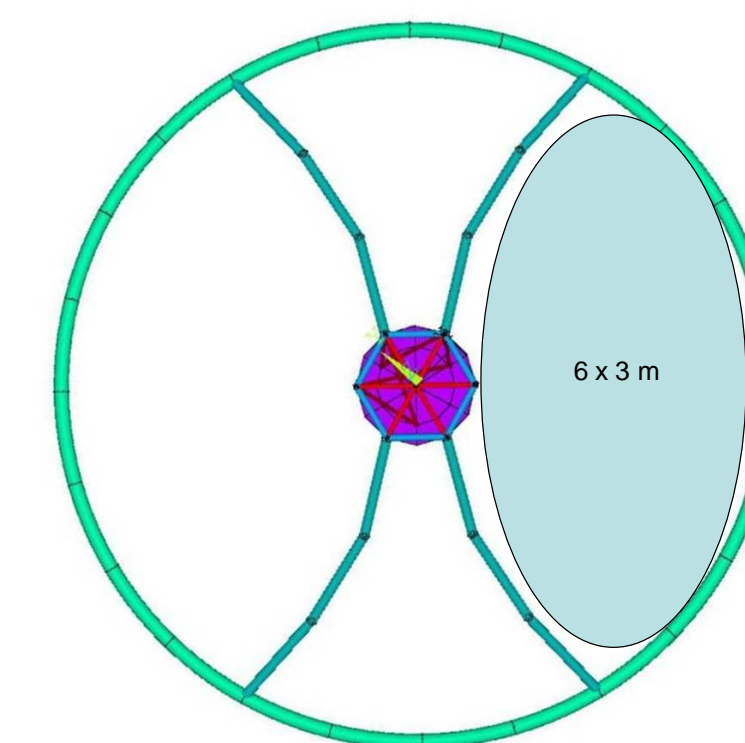
To maximize UV throughput, ATLAST-8m employs body pointing (via star trackers, fine guidance sensors, reaction wheels, control moment gyros and active isolation) to place the science object of interest directly onto the entrance slit of the UV spectrograph. ATLAST-8m uses two solar panels on 10 m deployable booms to balance solar pressure exerted on its sunshade tube. Analysis shows that only 35 N-m-s momentum is required for 6.25 days of continuous high-precision pointing. Reaction wheels have 698 N-m-s of storage for a minimum of 4500 minutes of continuous observation time and a maximum of 180,000 minutes.



Unobscured Coronagraphy Aperture

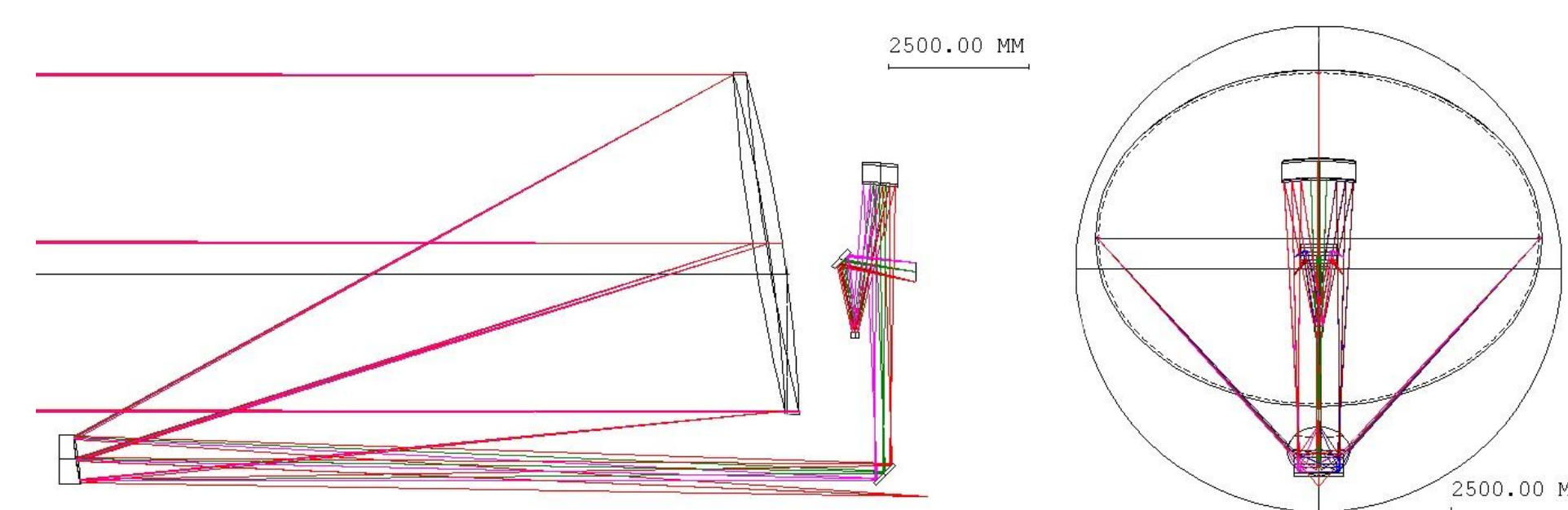
Conventional X-configuration SM spiders produce orthogonal diffraction which prevents a mask-based (Lyot-type) internal coronagraph from achieving the desired 10⁻¹⁰ starlight suppression. Two options were studied to provide an unobscured aperture to maximize the starlight suppression performance of an internal coronagraph.

Spider Options: One idea is to use a double arched spider which creates two 3 x 6 meter elliptical clear apertures – approximately the same size as the original TPF-C. With relay pupil aperture masking, it is possible to place an internal coronagraph behind each sub-aperture.



Another spider idea is to jettison two struts on orbit leaving a single linear spider to which an internal linear occulting mask would be completely 'blind'. Dynamic stability analysis is required for this idea.

Off-Axis Design: An off-axis configuration was designed. Because the PM is off-axis, for ease of manufacture and alignment, the PM to SM distance is set at 12 meters. Because the SM is off-axis and the Ares V fairing cylindrical height is only 9.7 meters (compared to 17.2 m in the center), it is not possible to have a fixed secondary mirror. Thus, the SM tower must fold for launch. Also, because the Ares V has an 8.8 meter diameter payload dynamic envelop, the design is limited to a 6 x 8 meter elliptical aperture 6 meters off axis. Finally, in addition to the on-axis CASS focus, there is only one WFOV TMA focus.



Conclusions

The ATLAST Astrophysics Concept Study developed a detailed point design for an 8-m monolithic aperture UV/OIR space telescope called ATLAST-8m. The mission concept takes full advantage of the unprecedented mass and volume capabilities of NASA's planned Ares V cargo launch vehicle. The key fundamental design paradigm for ATLAST-8m is simplicity. Simple high TRL technology offers lower cost and risk. The Ares V capacities allow one to use mass to buy down performance, cost and schedule risk. An 8-meter class UV/optical space observatory with its very high angular resolution, very high sensitivity, broad spectral coverage, and high performance stability offers the opportunity to answer some of the most compelling science questions.

8-meter Engineering Study Team

ATLAST 8-meter Engineering Team includes but is not limited to:

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